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Natural Resource Program Center

Monitoring of Rocky Intertidal Communities of Redwood National and State Parks, California

2006-2007 Annual Report

Natural Resource Technical Report NPS/KLMN/NRTR—2009/274

ON THE COVER
Researchers sampling the intertidal community at Damnation Creek, Redwood National and State Parks.
Photograph by: D. Lohse

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the Klamath Inventory and Monitoring Network website (http://science.nature.nps.gov/im/units/klmn/Reports/Monitoring_Reports.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

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Abstract

This report presents the results of two years, 2006 and 2007, of monitoring the rocky intertidal community at three sites within the Redwood National and State Parks (RNSP) in Del Norte County, California. These sites are part of MARINe (Multi-Agency Rocky Intertidal Network), a regional intertidal monitoring network sponsored by the Minerals Management Service (MMS), with additional funding and support from local and state governments, universities, and private organizations (see www.marine.gov). Funding for RNSP sampling is provided by the NPS through a collaborative agreement with the University of California at Santa Cruz.

This monitoring program, adapted from MARINe protocols, was designed to identify and follow temporal trends in populations of specific indicator organisms. A twice-yearly sampling included: 1) permanent plots to monitor important sessile invertebrate and algal species, 2) plots to monitor the ochre star (*Pisaster ochraceus*), and 3) transects to monitor surfgrass (*Phyllospadix* spp.). These data are used to describe seasonal and annual community changes and explore broader spatial and temporal trends.

The Rocky Intertidal Monitoring Program is off to a successful start, with a comprehensive, field-tested protocol; 2 years of data collected during the development phase (2004 and 2005); and 3 years of full project implementation. The procedures for data collection, data management, data analysis, and reporting appear to be working well with no expected revisions to the protocol needed. This report and subsequent annual reports for the intertidal monitoring program are intended primarily as administrative reports. More comprehensive trend analyses of the data will be included in the program’s 5-year reports, the first of which will be completed after the 2011 field season.

Acknowledgements

We thank the 2006-2007 field crew for their hard work and dedication to the project: Laura Anderson, Sara Worden, Melissa Redfield, Hilary Hayford, Carolina DaCosta, Galen Holt, Maya George, Kristen Kusic-Heady, Tish Conway-Cranos, and Cameron Balog. We also appreciate the field assistance from Redwood Park staff including David Anderson, Terry Hines, Kyle Max, Kelley Been, Heather Brown, and numerous volunteers. Sean Mohren, Eric Dinger, Daniel Sarr, Dennis Odion, and Bess Perry from the Klamath Network have provided editing, technical, and data assistance.

Introduction

Rocky Intertidal Monitoring

Several coastal parks, including Cabrillo National Monument (CNM) and Channel Islands National Park (CINP), have begun intertidal monitoring programs to establish baseline datasets of their marine resources and to report changes in these resources (Davis and Halvorson 1996, Davis 2005). Monitoring intertidal assemblages allows changes to be tracked within and between communities over seasonal and yearly time scales. Such monitoring is critical for making informed management decisions. Tracking changes in these communities allows the "normal" limits of variation, as well as seasonal and long-term patterns, to be determined. Understanding these patterns is necessary for detecting anthropogenic changes resulting from disturbances such as oil spills or global climate change. The Minerals Management Service and PISCO (Partnership for the Interdisciplinary Studies of Coastal Oceans) have been working in concert with a number of academic and government organizations to monitor intertidal communities along the coast of California and Oregon. These Community Structure Surveys have been conducted by members of MARINe (Multi-Agency Rocky Intertidal Network) and PISCO and include over 20 coast-wide agencies.

The Community Structure Surveys were first established to determine abundance and distributional patterns of intertidal species along the southern California coast in the early 1990s (Ambrose et al. 1992). Since then, sites have been added to central and northern California, and Oregon. These surveys focused on examining temporal changes within permanent study plots. We have adapted the protocols used in these surveys (i.e., Engle 2005) for monitoring intertidal organisms within Redwood National and State Parks. This allows comparisons of population dynamics to be made with sites throughout the state. The addition of sites within the Redwood National and State Parks fills a noticeable gap in the geographic coverage of existing community surveys. Prior to this addition, no intertidal survey sites existed between southern Humboldt County and southern Oregon.

The specific monitoring objectives of the RNSP Rocky Intertidal Monitoring Program are:

- Monitor the temporal dynamics of target invertebrate, algal, and surfgrass species across accessible, representative, and historically sampled rocky intertidal sites at Redwood National and State Parks that can feasibly be monitored with the Network's intertidal monitoring budget ($30k/yr) to: (1) Evaluate potential impacts of visitor use or other park-specific activities; and (2) Provide monitoring information to help assess level of impacts and changes outside normal limits of variation due to oil spills, non-point source pollution, or other anthropogenic stressors that may come from outside the parks.
- Determine status through time of morphology, color ratios, and other key parameters describing population status (e.g., size, structure) of the selected intertidal organisms.
- Integrate with and contribute to a monitoring network spanning a broad geographic region, in order to evaluate trends at multiple scales, from the park to region-wide, taking advantage of greater sample sizes at broader scales.
- Detect and document invasions, changes in species ranges, the spread of diseases, and the rates and scales of processes affecting the structure and function of rocky intertidal populations and communities to better understand normal limits of variation.

The specific measurement and analysis objectives of the program are:

- Provide a photographic record of sessile invertebrates and algae (and potentially oil and other non-point source pollutants) using fixed plots (photoplots) as reference.
- Determine the abundance (percent cover) of organisms within select fixed plots (interchangeably called photoplots or photoquadrats).
- Within fixed plots, determine the abundance of sea stars, snails, chitons, limpets, and crabs (mobile invertebrates) that may serve as an indicator of overall or specific ecosystem health.
- Determine surfgrass abundance by measuring cover along fixed point-intercept transects.
- Identify changes that are inconsistent with the established baseline conditions, whether they are park-specific or broader in scale, and whether there are potential management actions needed to mitigate them.
- Prepare annual summary reports and 5-year, peer reviewed trend analysis reports showing data relevance following National Park Service reporting guidelines. Reports will display any major (>50%) changes in the abundance of target taxa between sampling intervals as a highlight for potential management actions.

The RNSP Rocky Intertidal Monitoring Program (Ammann and Raimondi 2008) has been developed as a rigorous, park-based approach that integrates with a long-term, spatially extensive program. The national parks are promoting the importance of marine resources by establishing long-term monitoring programs supported by the public and scientific community. This effort will translate into a greater appreciation of these resources and an awareness of the importance of maintaining them for future generations.

Study Area

Three rocky intertidal sites were selected for monitoring within RNSP. The selected sites are Enderts Beach, Damnation Creek, and False Klamath Cove (Figure 1). The sites are approximately 5 km apart and span the nearly 30 km of rocky intertidal habitat present in RNSP.

Enderts Beach is at the northern edge of RNSP, located at the southern end of Crescent Beach. The site consists of a large, gently sloping bench (approximately 100 m wide) and a series of three smaller benches separated by surge channels and cobble beds. Rocky intertidal monitoring occurs on the three rocky benches.

Damnation Creek is 5 km south of Enderts Beach and 6.5 km north of False Klamath Cove. It is an extensive rocky bench cut by channels, with a few large sedentary boulders at its seaward edge. The landward edge of the bench has an accumulation of smooth cobble. Although the site is near the mouth of Damnation Creek, the monitoring plots are established far enough away from the creek's outflow to avoid direct freshwater input.

False Klamath Cove is located just south of Wilson Creek, about 8 km north of the Klamath River mouth. This site has variable substrata that range from coarse sand to large boulders. There is potential for temporal variation in sand scour and boulder movement. The intertidal study site is peninsula-like with the ocean to the north and south and a sea stack (approximately 75 m tall and 100 m wide) at the west end. The peninsula stretches approximately 250 m long with a width of approximately 100 m. It is a gently sloping field of boulders and small rock benches. Sampling is restricted to large sedentary boulders and small rocky benches.

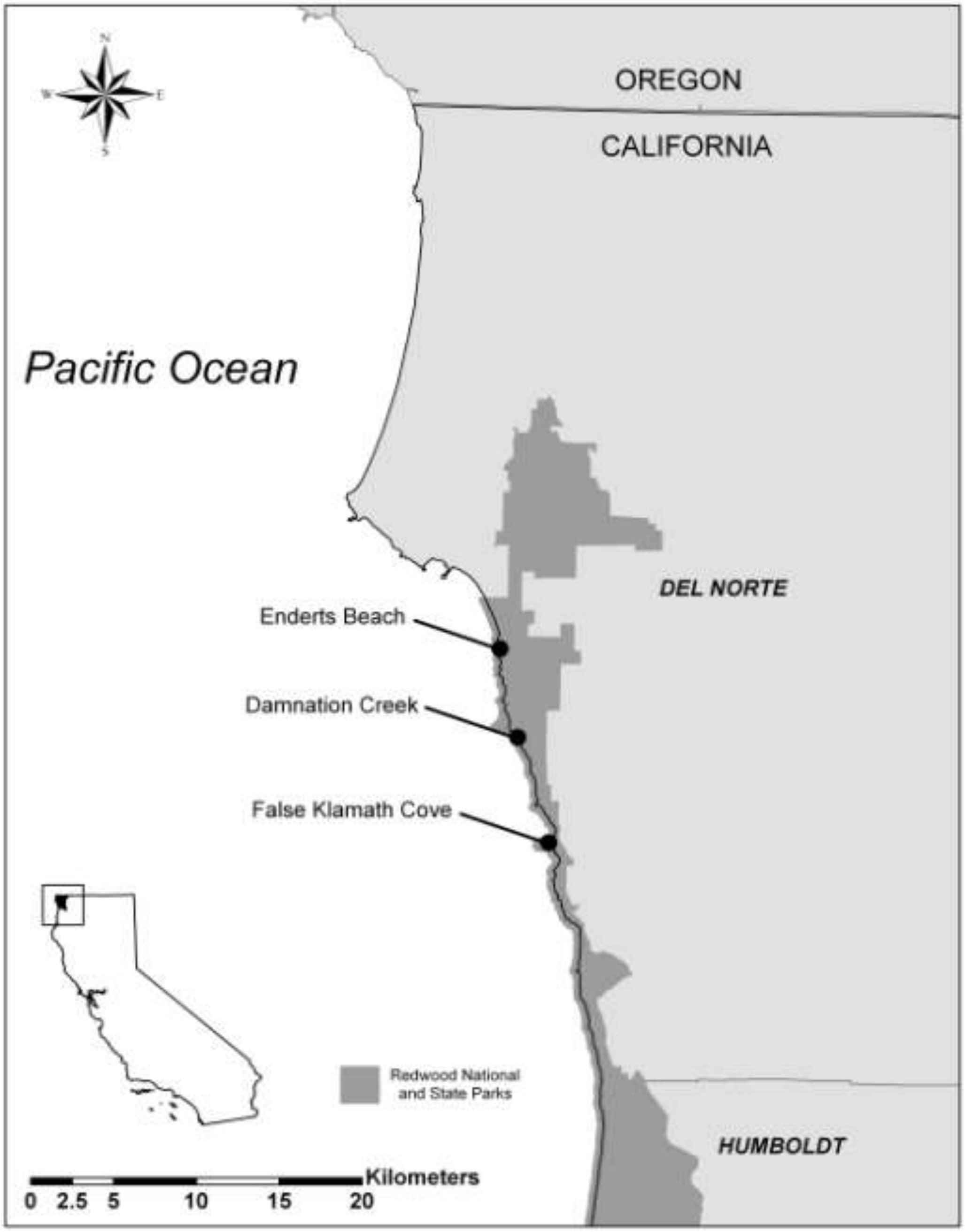

Figure 1. Map of northern Redwood National and State Parks, showing locations of rocky intertidal study sites.

Methods

Sample Design
The methods used for monitoring algal and invertebrate species in RNSP are based on the protocols developed by MARINe (**www.marine.gov**) and are explained in detail in Ammann and Ramondi (2008). In brief, the abundance of ecologically important organisms are measured in discrete, fixed plots that have been established in targeted assemblages. Using fixed plots allows the dynamics of species to be monitored with reasonable sampling effort and provides greater power to detect changes over time. Smaller (50 x 75 cm) plots are used to monitor sessile (or relatively non-motile) algae and invertebrates, while larger plots are used to sample more mobile species.

Field Log
Field logs are kept to provide a record of any general observation made during the surveys at the monitoring sites including weather conditions, participants, changes to or deviations from the protocols, and any unique or unusual occurrences. Physical and weather-related conditions are collected initially upon reaching the site, as are counts of birds, marine mammals, and humans. Also noted is the site-wide abundance and condition (e.g., reproductive state, bleached) of a set list of species, including some not targeted in the permanent plots. Researchers for MARINe working at sites from San Diego to the Oregon/Washington border have an identical list of core species for which relative abundance (including absence) and condition are recorded. This standard species list allows monitoring groups to consistently make general observations about species not targeted in specific plots. The relative abundance and recruitment categories are qualitative, but are based on extensive knowledge of the sites and species distributions. In order to report annual averages of these data, the categories were given numeric values (e.g., Abundant=5, Rare=1) and averaged.

Photoplots
At each site, photoplots (50 x 75 cm in size) are used to record changes in abundance (measured as % cover) of conspicuous, abundant, and ecologically important species, including mussels (*Mytilus californianu*s), barnacles (*Chthamalus dalli/Balanus glandula*), and three species of algae (turfweed [*Endocladia muricata*], dwarf rockweed [*Pelvetiopsis limitata*], and rockweed [*Fucus gardneri*]) (**Figure 2**). The natural history of target organisms is provided in Appendix B.

Figure 2. Photographs depicting the five target species sampled in permanent photoplots.

Five photoplots were established for each species (Table 1), and the location of each plot was chosen to maximize the abundance of the targeted species. Because the rockweed (*Fucus*) was not abundant at Enderts Beach, and dwarf rockweed (*Pelvetiopsis*) was not abundant at Damnation Creek, no plots were set up to monitor these species at those sites. At Damnation Creek, five additional mussel plots were established in the outflow of Damnation Creek, where salinity is often much lower than in the other mussel plots (Cox and McGary 2006). At low tide, the salinity of the water surrounding the mussel plots, located near Damnation Creek, has been recorded as low as 22 ppt compared to the average ocean salinity between 32-35 ppt.

The photoplots were marked by three permanent bolts and are photographed using a digital camera mounted on a PVC photo-framer. The abundances (% cover) of all sessile species in the photoplots were determined using a rectangular grid of 100 uniformly spaced points. This grid is superimposed over the plot, and the taxon under each point was identified.

Table 1. Summary of photoplot species monitored at RNSP sites, including number of replicate plots.

	Mussels	**Barnacles**	**Rockweeds/Sessile algae**		
Site	***Mytilus* spp.**	***Chthamalus/ Balanus***	***Pelvetiopsis limitata***	***Endocladia muricata***	***Fucus gardneri***
Enderts Beach	5 plots	5 plots	5 plots	5 plots	-----
Damnation Creek	10 plots*	5 plots	-----	5 plots	5 plots
False Klamath Cove	5 plots	5 plots	5 plots	5 plots	5 plots

*Five mussel plots are located away from creek outflow and five plots are located near the outflow of Damnation Creek.

Mobile Invertebrates

Photoplots were also used to measure the abundance (density) of mobile invertebrates. With the exception of burrowing organisms and amphipods, all mobile invertebrates within each photoplot are counted. For select species, such as black turban snails (*Tegula funebralis*) and dogwinkles (*Nucella emarginata* and *N. canaliculata*), the size distribution is determined (measured at its longest axis using calipers) of the first 10 individuals encountered and this information is used to determine size distributions.

Barnacle Recruitment
Small clearings (10 x 10 cm), established near the barnacle photoplots, are sampled in the summer to measure barnacle recruitment. Each year the acorn barnacles (*Balanus glandula* and *Chthamalus dalli*) (Figure 3) that recruit into these plots are counted with a hand lens, after which the plots are scraped clean. These plots were established at the sites in the summer of 2006, and were first sampled in the summer of 2007. These plots are sampled annually each summer in order to be comparable with other plots at other sites in northern California and Oregon.

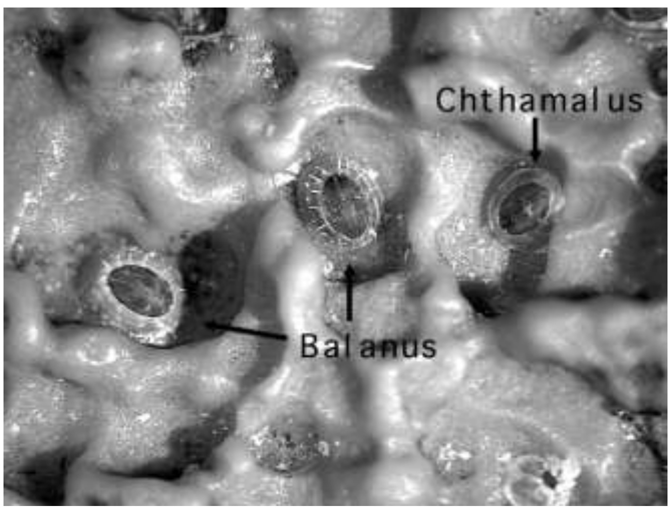

Figure 3. Image (10x) of barnacle recruits (*Balanus glandula* and *Chthamalus dalli*) taken through a microscope.

Sea Stars
Large, permanent plots are used to monitor the size and abundance of the ochre sea star, *Pisaster ochraceus*. Three plots are monitored at Damnation Creek and False Klamath Cove, while two plots are sampled at Enderts Beach. These plots were established in areas where sea stars are abundant and, thus, are not intended to quantify the overall density of sea stars at the site. Each ochre sea star encountered is counted, measured, and its color (purple/orange) noted. Other rarer sea stars, such as the bat star (*Patiria miniata*), the giant sea star (*Pisaster giganteus*), the sunflower star (*Pycnopodia helianthoides*), the six-armed star (*Leptastarias hexactis*), and leather sea star (*Dermasterias imbricate*) are also counted when encountered.

Surfgrass
Permanent line transects are used to measure the abundance (% cover) of surfgrass (*Phyllospadix scouleri/torreyi*) and associated species at Damnation Creek (does not abundantly occur at the

other sites). Each transect is 10 m long and is sampled by noting the species under each 10 cm mark.

Sea Surface Temperature

A temperature logger was deployed at each site to measure sea-surface temperature. These small units (Tidbit Temperature data loggers, Onset Computer Corporation) were attached to the rock below the mussel zone and are set to record temperatures every 15 minutes. The units were changed out during each site visit, data downloaded, and then reset for use again. Only those times of the day when the probe is underwater are used to calculate sea-surface temperature.

Data Collection and Entry

The RNSP intertidal sites are sampled twice each year (summer and fall/winter) during times when there are good negative low tides. The summer survey usually occurs in May or June and the fall/winter survey sometime in November or December. All data for this report were collected between May 28, 2006 and December 9, 2007 (Table 2). Each site requires a full day of sampling by a team of six field biologists.

After the completion of each survey, researchers review the data forms for missing or incorrectly recorded data. Once complete, the data are entered into the MARINe Data Management System (MDMS), a system that provides a uniform data acquisition, data analysis, and information storage and retrieval system for all MARINe institutions. Data from field logs, photoplots, sea star plots, and surfgrass transects are entered into the MARINe Access database (version 3). Data for mobile invertebrate counts are entered into a Microsoft Excel spreadsheet for analysis.

Data Analysis

Basic summary statistics are used to examine variations in abundance for the key species found in the photoplots (e.g., barnacles [*Chthamulus*, *Balanus*, etc.], mussels [*Mytilis* spp.], and rockweed species [e.g., *Pelvetiopsis limitata*]) and line transects (e.g., surfgrass [*Phyllospadix* spp.]). Mean percent cover values are presented for each site (based on pooled values for all plots in each zone) in summer and fall sampling periods. This report covers 2 years of data; however, future analysis of trends will be based on a longer time series (>5 years).

Table 2. Sampling locations and dates for RNSP rocky intertidal monitoring.

Site	Site Code	Coordinates (Decimal Degree)* Latitude	Longitude	Summer 2006	Fall 2006	Summer 2007	Fall 2007
False Klamath Cove	FKC	41.59476	124.10643	29-May	18-Dec	5-Jun	9-Dec
Damnation Creek	DMN	41.65249	124.12784	30-May	19-Dec	4-Jun	7-Dec
Enderts Beach	END	41.69000	124.14257	28-May	20-Dec	3-Jun	8-Dec

* Site coordinates from datum NAD83, source BLM.

Results

Raw data used to create this report are available upon request through MARINe or the National Park Service. Please contact the author with requests.

Field Log

Species List and Conditions

The general observations made for each survey are presented in **Error! Reference source not found.**3. During each sampling trip, observations were recorded about the general physical and weather-related conditions at the site. Some of the data recorded during each visit includes: tidal information; temperature; wind; and levels of rain, sand scour, trash, plant wrack (dried seaweed), dead animals, and trash.

Site-wide abundances of the core and optional species (see definition in Appendix A) monitored with the field log are presented in **Error! Reference source not found.**4. Recruitment was noted for several species and the average recruitment is shown for species where recruitment was commonly observed. Damage, bleaching, and flowering were also recorded for species on the field log.

Shorebirds and Mammals

Summaries of the common mammals and shorebirds observed during the RNSP surveys are presented in Table 5 and Table 6, respectively. These data represent the greatest number of each species observed at any one time on or near the sampled reef. They are not intended as census data but rather as field observations. The numbers of humans noted is not intended to be visitation data.

Table 6 summarizes the common list of birds that all rocky intertidal MARINe monitoring groups record along the California and Oregon coast. Table 7 lists the additional bird species that were noted on the reef or flying over the sampling sites at one or more occasions during 2006-07.

Table 3. Field conditions for sampling trips in 2006-2007 at three intertidal sites within RNSP. Codes for levels indicated are L=low, M=medium, H=high, ND=No data.

Season Code	Site ID	Start Time	End time	Low Tide Level	Low Tide Time	Swell Surge	Wind	Rain	Recent Rain	Sedi-ment Level	Scour	Rock Move-ment	Plant Wrack	Drift-wood	Shell Debris	Dead Animals	Trash
SU06	DMN	6:00	12:30	-1.2	8:50	L	L	0	L	M	L	L	L	M	L	0	L
FA06	DMN	13:30	18:30	-0.9	17:15	H	L	0	M	M	L	M	L	M	L	0	0
SU07	DMN	6:50	12:00	-1.1	8:55	M	L	L	0	H	L	M	L	L	L	0	L
FA07	DMN	13:00	17:30	-0.1	16:30	M	M	0	H	M	L	0	0	L	L	0	0
SU06	END	5:30	10:30	-1.9	7:23	L	L	ND	H	M	L	L	L	M	H	0	0
FA06	END	14:00	18:15	-0.9	18:10	M	H	L	M	L	L	L	ND	L	L	ND	ND
SU07	END	6:00	11:45	-1.2	8:15	L	M	0	0	L	L	L	L	L	L	0	L
FA07	END	13:30	17:30	-0.4	17:15	M	M	0	H	L	0	0	M	M	L	0	0
SU06	FKC	5:45	12:00	-1.6	8:07	L	L	0	L	H	0	M	L	H	M	0	L
FA06	FKC	13:30	18:00	-0.4	16:30	M	L	0	M	M	L	M	L	H	L	0	0
SU07	FKC	6:30	12:30	-0.9	9:38	L	L	L	L	H	L	L	L	M	L	L	L
FA07	FKC	14:30	18:15	-0.5	17:45	M	L	0	H	M	L	L	L	M	L	L	L

Table 4. Average abundance category for core and optional species (see definition in Appendix A) from field list at three sites within RNSP during the 2006-2007 sampling trips. Abundance codes: 0= not detected, R=rare, U=uncommon, P=present, C=common, A=abundant. Recruitment codes: L=low, M=medium, H=high.

Core Species	Common Name	Average Abundance	Average Recruitment
Red Algae			
Ahnfeltiopsis linearis	red algae	R	
Caulacanthus ustulatus	-----	0	
Chondracanthus canaliculatus	-----	R	
Constantinia simplex (optional)	cup and saucer seaweed	R	
Endocladia muricata	turfweed	A	L
Gloiopeltis furcata (optional)	jelly moss	U	
Mastocarpus papillatus	turkish washcloth	C	M
Mazzaella affinis	-----	U	
Mazzaella spp. (=*Iridaea* spp.)	iridescent weed	C	
Neorhodomela larix	blackpine	C	
Odonthalia spp. (optional)	tooth branch	C	
Plocamium spp. (optional)	like braided hair	U	
Porphyra spp.	Nori	A	
Green Algae			
Cladophora columbiana	pin-cushion algae	P	
Ulva/Enteromorpha	sea lettuce	P	
Brown Algae			
Egregia menziesii	feather boa kelp	P	
Eisenia arborea	southern sea palm	0	
Petalonia spp.	sea petals	R	
Fucus gardneri	rockweed	A	L
Halidrys dioica/Cystoseira spp.	bladder chain kelp	R	
Saccharina (=*Hedophyllum*) *sessile*	sea cabbage	P	
Hesperophycus californicus	western alga	0	
Pelvetiopsis limitata	dwarf rockweed	C	M
Postelsia palmaeformis	Sea palm	R	
Sargassum muticum	wireweed	0	
Scytosiphon spp	leather tube	U	
Silvetia compressa	slender rockweed	R	
Surfgrass			
Phyllospadix scouleri/torreyi	surfgrass	C	

Table 4. Average abundance category for core and optional species (see definition in Appendix A) from field list at three sites within RNSP during the 2006-2007 sampling trips. Abundance codes: 0= not detected, R=rare, U=uncommon, P=present, C=common, A=abundant. Recruitment codes: L=low, M=medium, H=high (continued).

Core Species	Common Name	Average Abundance	Average Recruitment
Gastropods			
Acanthinucella spp.	unicorn snail	0	
Haliotis cracherodii	black abalone	0	
Katharina tunicata	black leather chiton	P	
Littorina spp.	periwinkle snail	A	M
Lottia gigantea	owl limpet	0	
Nucella canaliculata	channeled dogwinkle	U	
Nucella emarginata/ostrina	striped dogwinkle	C	L
Ocenebra circumtexta	circled rocksnail	0	
Tegula spp.	turban snail	C	M
Bivalves			
Mytilus californianus	California mussel	C	M
Septifer bifurcates	branch-ribbed mussel	0	
Crustaceans			
Balanus glandula	acorn barnacle	A	M
Balanus nubilis (optional)	giant acorn barnacle	R	
Chthamalus dalli/fissus	small acorn barnacle	C	M
Hemigrapsus nudus (optional)	purple shore crab	P	
Idotea spp. (optional)	Isopod	C	
Ligia occidentalis	western sea roach	U	
Pachygrapsus crassipes	lined shore crab	P	L
Pollicipes polymerus	gooseneck barnacle	P	L
Semibalanus cariosus	thatched barnacle	P	
Tetraclita rubescens	red thatched barnacle	0	
Anemones			
Anthopleura elegantissima/sola	sea anemone	C	
Echinoderms			
Pisaster ochraceus	ochre seastar	C	M
Strongylocentrotus purpuratus	purple urchin	R	
Polycheate worms			
Phragmatopoma californica	sand castle worm	R	

Table 5. Mammals observed at RNSP monitoring sites in 2006 and 2007 (maximum seen at any one time).

Site ID	Survey Season	Harbor Seal *Phoca vitulina*	California Sea Lion *Zalophus californianus*	River Otter *Lontra canadensis*	Humans on reef	Humans on sand
DMN	SU06			1		
DMN	FA06					
DMN	SU07				1	
DMN	FA07			1	2	
END	SU06				1	5
END	FA06	1				
END	SU07					1
END	FA07	1				
FKC	SU06				4	10
FKC	FA06					2
FKC	SU07		5	1		6
FKC	FA07					
	total 2006	**1**	**0**	**1**	**5**	**17**
	total 2007	**1**	**5**	**2**	**3**	**7**

Table 6. Common shorebirds observed at RNSP monitoring sites in 2006 and 2007 (maximum seen at any one time).

Site ID	Season	Great Blue Heron *Ardea herodias*	Cormorant *Phalacrocorax spp.*	Gull *Larus spp.*	Oyster-catcher *Haematopus bachmani*	Pelican *Pelicanus occidentalis*	Tern *Sterna hirundo*
DMN	SU06		1	4	3		
DMN	FA06				12		
DMN	SU07				5		
DMN	FA07			3		1	2
END	SU06				3		
END	FA06		1		3		
END	SU07		2	3	2	25	
END	FA07		2	6			
FKC	SU06	1	4		5		
FKC	FA06			4	2		
FKC	SU07			1	3		
FKC	FA07			1	2		1
total 2006		**1**	**6**	**8**	**28**	**0**	**0**
total 2007		**0**	**4**	**14**	**12**	**26**	**3**

Table 7. List of additional bird species observed at RNSP intertidal sites during sampling.

Common Name (genus species)
Bald Eagle (*Haliaeetus leucocephalus*)
Brandt's Cormorant (*Phalacrocorax penicillatus*)*
Common Murre (*Uria aalge*)
Double Crested Cormorant (*Phalacrocorax auritus*)
Glaucous gull (*Larus hyperboreus*)*
Kingfisher (*Megaceryle alcyon*)
Osprey (*Pandion haliaetus*)
Pelagic Comorant (*Phalacrocorax pelagicus*)*
Pigeon Guillemot (*Cepphus columba*)
Raven (*Corvus corax*)
Tree Swallow (*Tachycineta bicolor*)
Turkey vulture (*Cathartes aura*)
Western Gull (*Larus occidentalis*)*
Western Grebe (*Aechmophorus occidentalis*)
Vaux's Swift (*Chaetura vauxi*)

*Species that are lumped to genus level in Table 6.

Photoplots

Changes in abundance of species found in the photoplots are presented in Figure 4 thru Figure 8. The figures include taxa that comprised at least 5% of the plot. To date, monitoring data have indicated disturbance and recovery in some plots, for sessile organisms such as barnacles and turfweed (*Endocladia muricata)*. Other plots have been more stable over the course of this study. The following preliminary summaries are from observations of only 2 years of data and are not trend analyses.

Barnacles (Chthamalus dalli and Balanus glandula)

Barnacle abundances varied over time and among sites (Figure 4). *Balanus glandula* increased in abundance, while the abundance of the small acorn barnacle, *Chthamalus dalli*, decreased. At Enderts Beach and Damnation Creek, *Chthamalus* was more dominant in 2006, while in 2007 *Balanus* was more abundant.

Turfweed (Endocladia muricata)

Turfweed (*Endocladia muricata*) abundance varied seasonally and was most abundant during the summer surveys (Figure 5). However, even during the fall, abundances remained high; except for Enderts Beach in 2007 when it dropped below 50% cover (Figure 5). The pattern observed showed a negative relationship between the abundance of turfweed and the amount of open space (rock).

Rockweed (Fucus gardneri)

The rockweed (*Fucus gardneri*) abundance (Figure 6) did not vary seasonally and, except for False Klamath Cove during the fall 2007 survey, remained high (>75%) throughout 2006 and 2007. In fall 2007, at False Klamath Cove, rockweed abundance declined to 50% and the abundance of non-coralline crust increased.

Dwarf Rockweed (Pelvetiopsis limitata)

The dwarf rockweed (*Pelvetiopsis limitata*) abundance varied seasonally at Enderts Beach but not at False Klamath Cove (Figure 7). Declines in dwarf rockweed cover corresponded to increases in the percent cover of rock and barnacles. At False Klamath Cove, dwarf rockweed cover remained between 50 and 70% throughout the study period. Rock, barnacles, and non-coralline crust accounted for most of the remaining cover.

California Mussel (Mytilus californianus)

Mussel (*Mytilus californianus*) cover remained high and fairly stable during 2006 and 2007 (Figure 8). Although the difference was small, abundances were slightly less at Enderts Beach, presumably due to a disturbance event, such as storm or harvesting, which removed mussels from several plots prior to 2006. By fall 2007, these plots had mostly recovered.

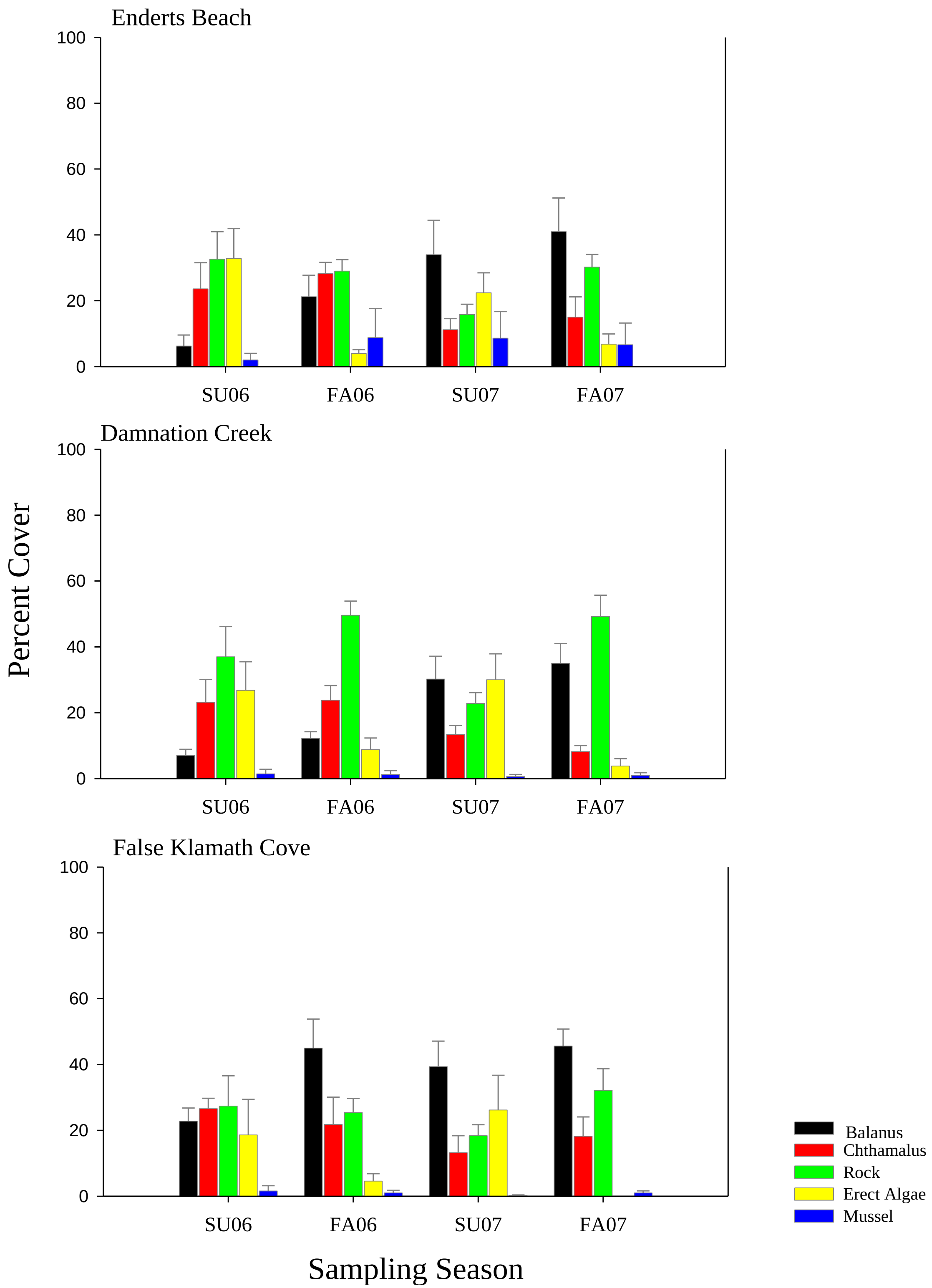

Figure 4. Mean abundance (± 1SE) of species in the barnacle (*Balanus/Chthamalus*) photoplots.

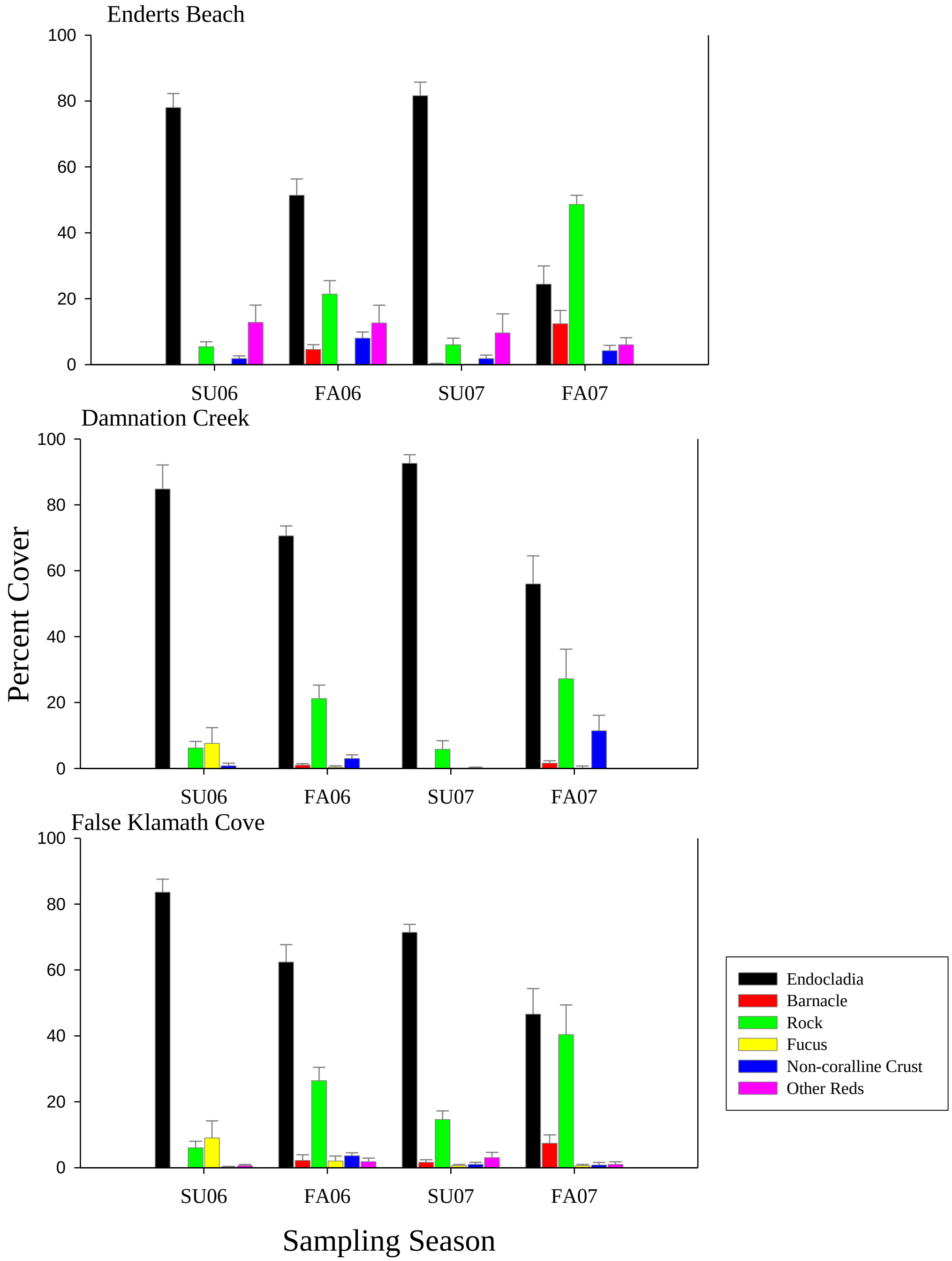

Figure 5. Mean abundance (± 1SE) of species in Turfweed (*Endocladia muricata*) photoplots.

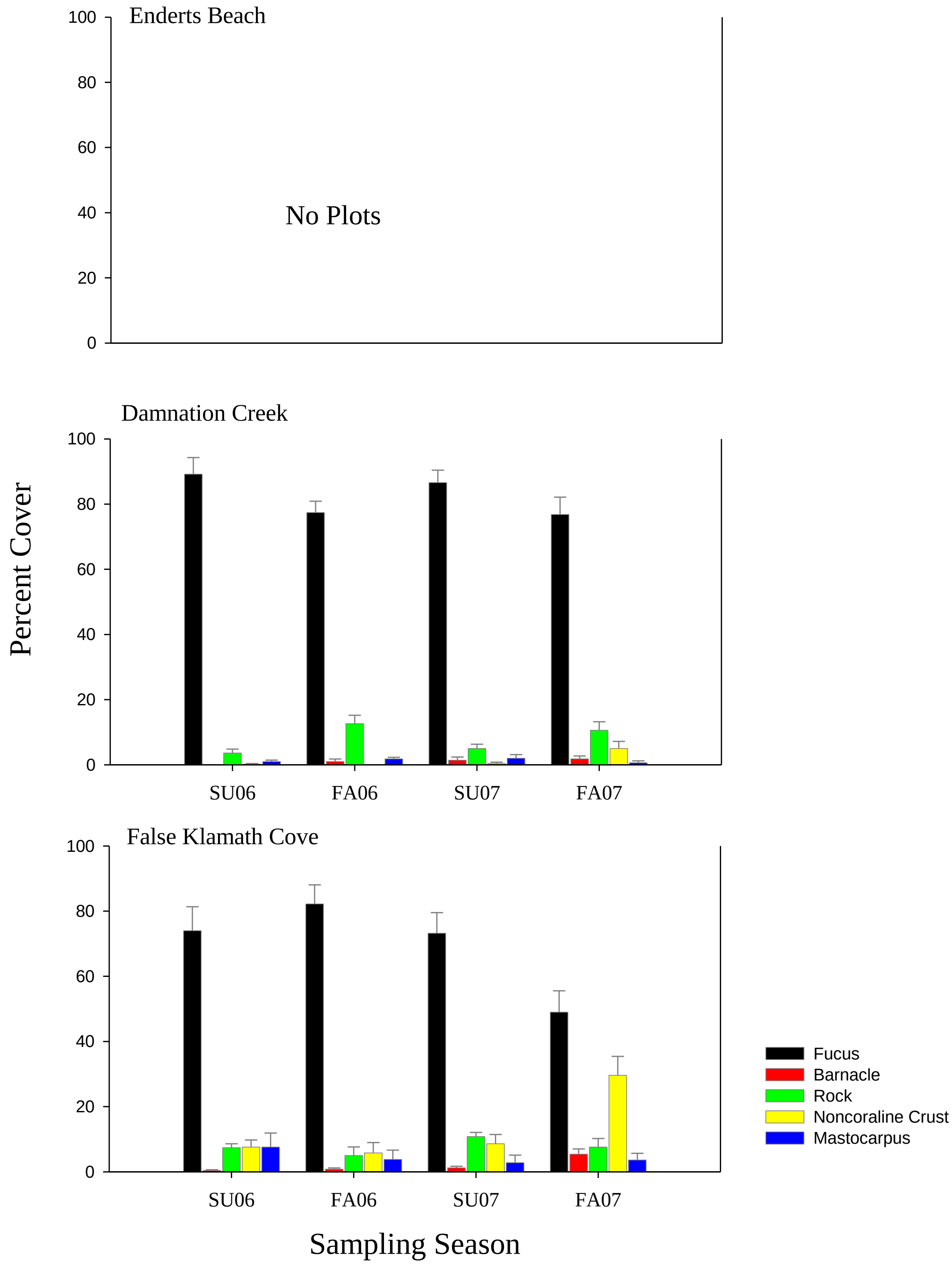

Figure 6. Mean abundance (± 1SE) of species in the Rockweed *(Fucus gardneri*) photoplots.

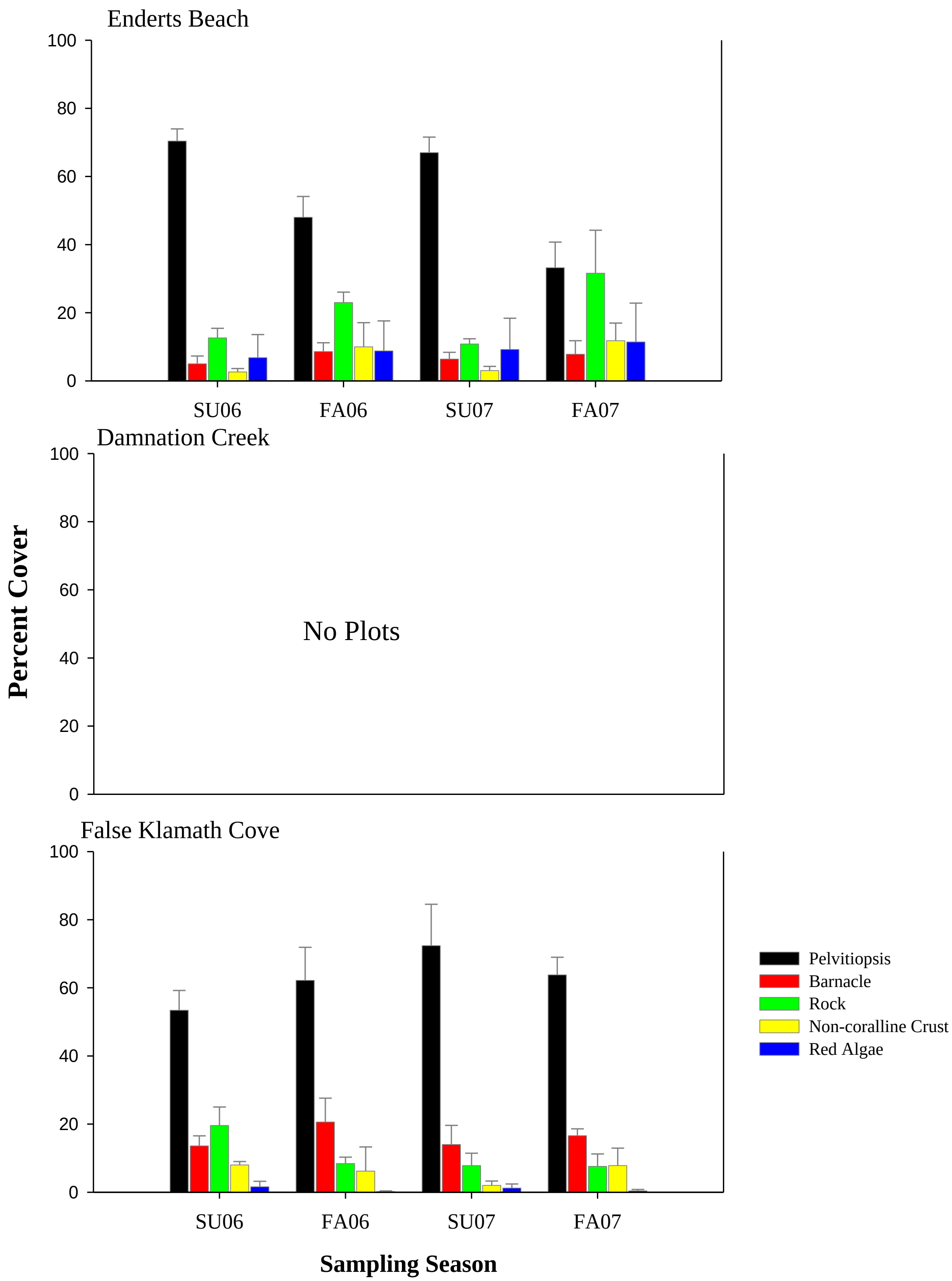

Figure 7. Mean abundance (± 1SE) of species in dwarf rockweed (*Pelvetiopsis*) photoplots.

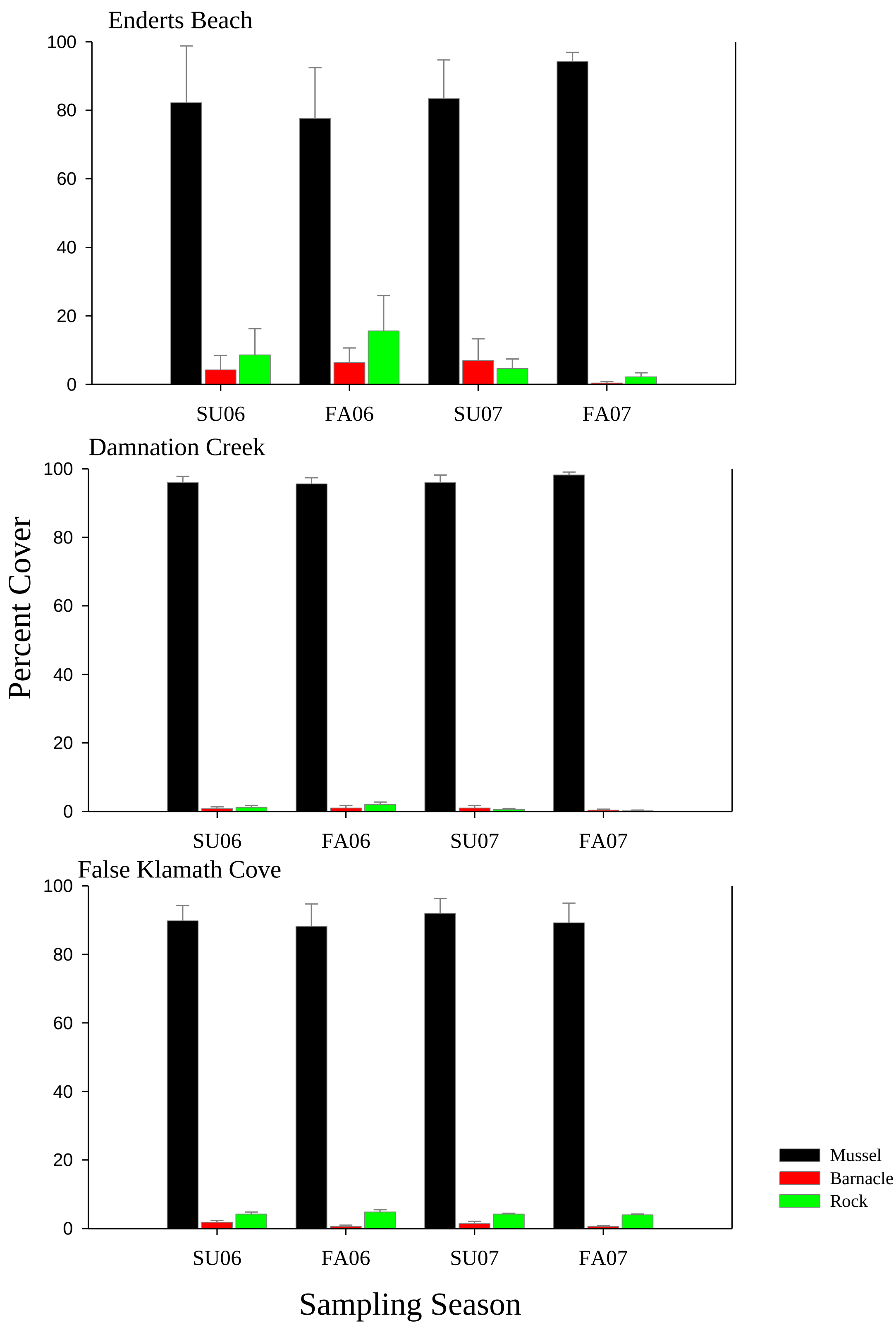

Figure 8. Mean abundance (± 1SE) of species in Mussel (*Mytilus*) photoplot.

Barnacle Recruitment

Because the recruitment clearings were established during the summer 2006 surveys, there is only recruitment data for 2007. There was a slight difference in recruitment among the three sites, a difference that was the same for both species of barnacle (Figure 9). *Chthamalus* recruitment exceeded *Balanus* recruitment at all sites for the sample period.

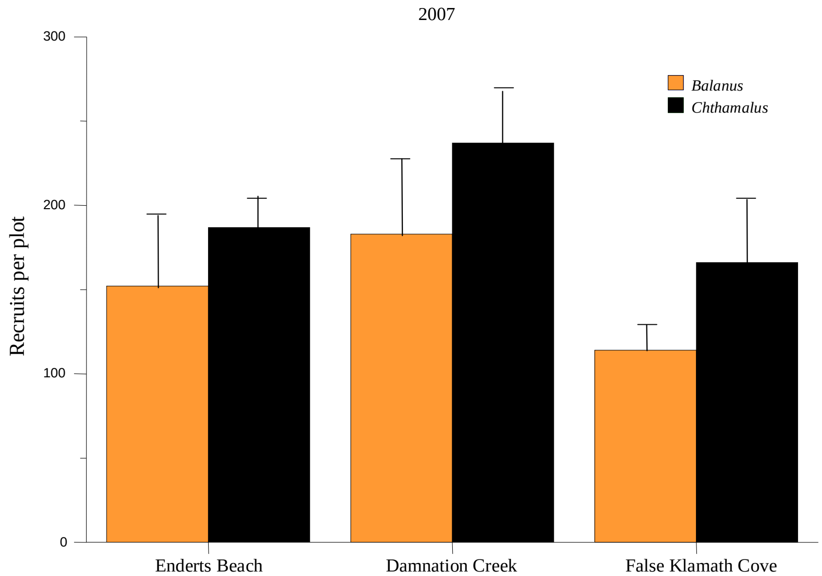

Figure 9. Mean annual recruitment (± 1SE) of barnacles in recruitment clearings at RNSP sites.

Mobile Invertebrates

A list of the mobile invertebrate taxa found within the photoplots during 2006 and 2007 is presented in Table 8. Changes in abundance of the more common taxa within RNSP are presented in Figures 10 thru 13. The less common mobile species found within the RNSP photoplots are presented in Table 9.

A total of 33 taxa of mobile invertebrates were found within the RNSP photoplots during 2006 and 2007 (Table 8). With a few exceptions, the abundance of most of these taxa tended to vary among the different types of plot. For example, Periwinkle snails (*Littorina* spp.) were by far the most common of these taxa, particularly in the barnacle plots where they often exceeded 1000 individuals per plot or 2500 per m^2 (Figure 10). Limpets were also abundant in the photoplots but were less common than littorines (Figure 10). Unlike littorines, their abundance did not seem to be a function of plot type.

The striped dogwinkle (*Nucella emarginata*), a predatory snail, was common at all sites, but was particularly abundant at Enderts Beach (Figure 11). It was most commonly found in the mussel and barnacle plots. In comparison, the channeled dogwinkle (*N. canalicula*), a related species, was found almost exclusively at Enderts Beach and only in the mussel plots (Figure 11).

At Damnation Creek and False Klamath Cove, the black turban snail (*Tegula funebralis*), a grazer, was primarily found in the mid-shore *F. garderni* plots, but its distribution at Enderts Beach was less restrictive (Figure 12). In comparison, at Enderts Beach, Gould's baby chiton (*Lepidochitona dentiens*), also a grazer, was found almost exclusively in the *Endocladia* plots, while at the other two sites its distribution spanned all levels of the shore (Figure 12).

The lined shore crab (*Pachygrapsus crassipes*) was mostly found in the mussel plots except at Enderts Beach, where it was also present in the barnacle plots (Figure 13). Hermit crabs (*Pagurus* spp.) were found almost exclusively in the *Endocladia* and *Fucus* plots (Figure 13). Similarly, most of the less common taxa were also found in the *Endocladia* and *Fucus* plots (Table 9).

Size distributions of turban snails have varied among and within sites over time (Figure 14). For example, large individuals (>20 mm) have been rare at Enderts Beach and uncommon at the other two sites, while the population at False Klamath Cove tends to be dominated by small (<10 mm) individuals. Size distributions of the striped dogwinkle were more similar across sites (Figure 14). Small individuals (<10 mm) were not common at any of the sites for the sampling periods summer 2006 through summer 2007. However, in fall 2007, many more small individuals were counted at all sites. The fall 2007 sample at False Klamath Cove was the only sampling trip where small (<10 mm) striped dogwinkles were more dominant than larger individuals.

Table 8. Mobile invertebrate taxa found in photoplots at RNSP sites during 2006-2007 sampling trips.

Taxa	Common Name
Gastropods (snails, limpets)	
Acanthiucella spp.	unicorn snail
Alia carinata	carinate dovesnail
Amphissa spp.	wrinkled/ variegated amphissa
Bittium eschrichtii	Bittium snail
Epitonium tunctum	tinted wentletrap
Fissurella volcano	volcano key-hole limpet
Lacuna spp.	chink shell
Unidentified Limpets	limpets
Littorina spp.	Periwinkle
Margarites spp.	*Margarites* spp.
Nucella canaliculata	chanelled dogwinkle
Nucella emarginata/ostrina	striped dogwinkle
Nucella lamellosa	frilled dogwinkle
Oceanebra circumtexta	circled rocksnail
Onchidella borealis	leather limpet
Tegula funebralis	black turban
Chitons	
Kathrina tunicata	black katy chiton
Lepidochitona dentiens	Gould's baby chiton
Lepidozona spp.	Lepidozona spp.
Mopalia spp.	hairy chiton
Nuttallina spp.	california spiny chiton
Crustaceans (crabs)	
Hemigrapsis nudis	purple shore crab
Idotea spp.	Vosnesesensky's isopod
Pachycheles spp.	thick-clawed porcelain crab
Pachygrapsis crassipes	striped shore crab
Pagurus beringanus	Bering hermit
Pagurus granosimanos	grainyhand hermit
Pagurus hirsutisculus	hairy hermit
Pagurus samuelis	blueband hermit
Petrolisthes spp.	flat porcelain crab
Pugettia spp.	kelp crab
Echinoderms	
Cucumaria spp.	sea cucumber
Leptasterias spp.	six-rayed star
Pisaster ochraceus	ochre star

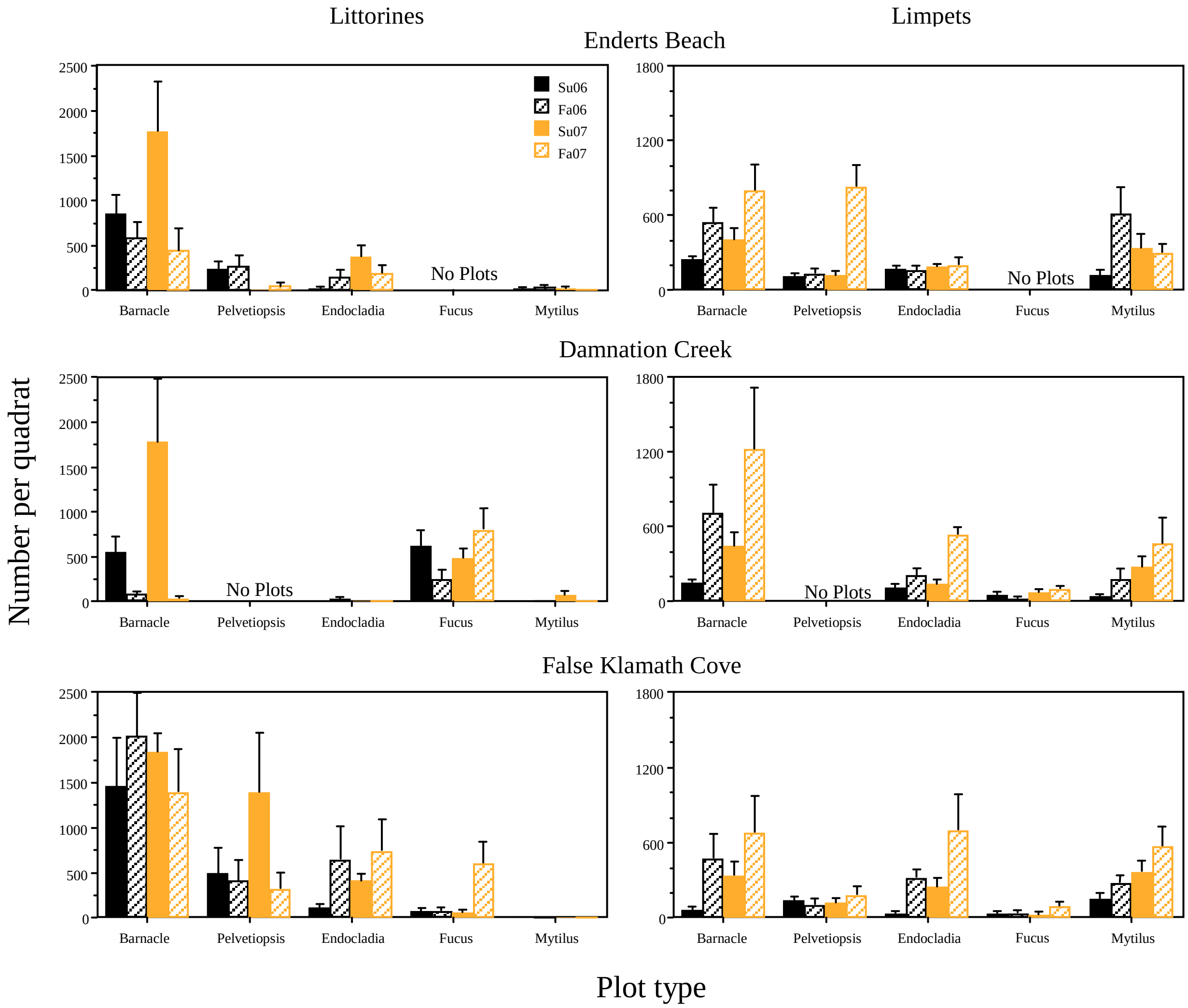

Figure 10. Mean abundance (± 1SE) of littorines and limpets in the various photoplots during the 2006-2007 sampling periods. Plot types arranged from high zone (Barnacle on far left) to mid zone (Mytilus on far right). Note different scales on y axes.

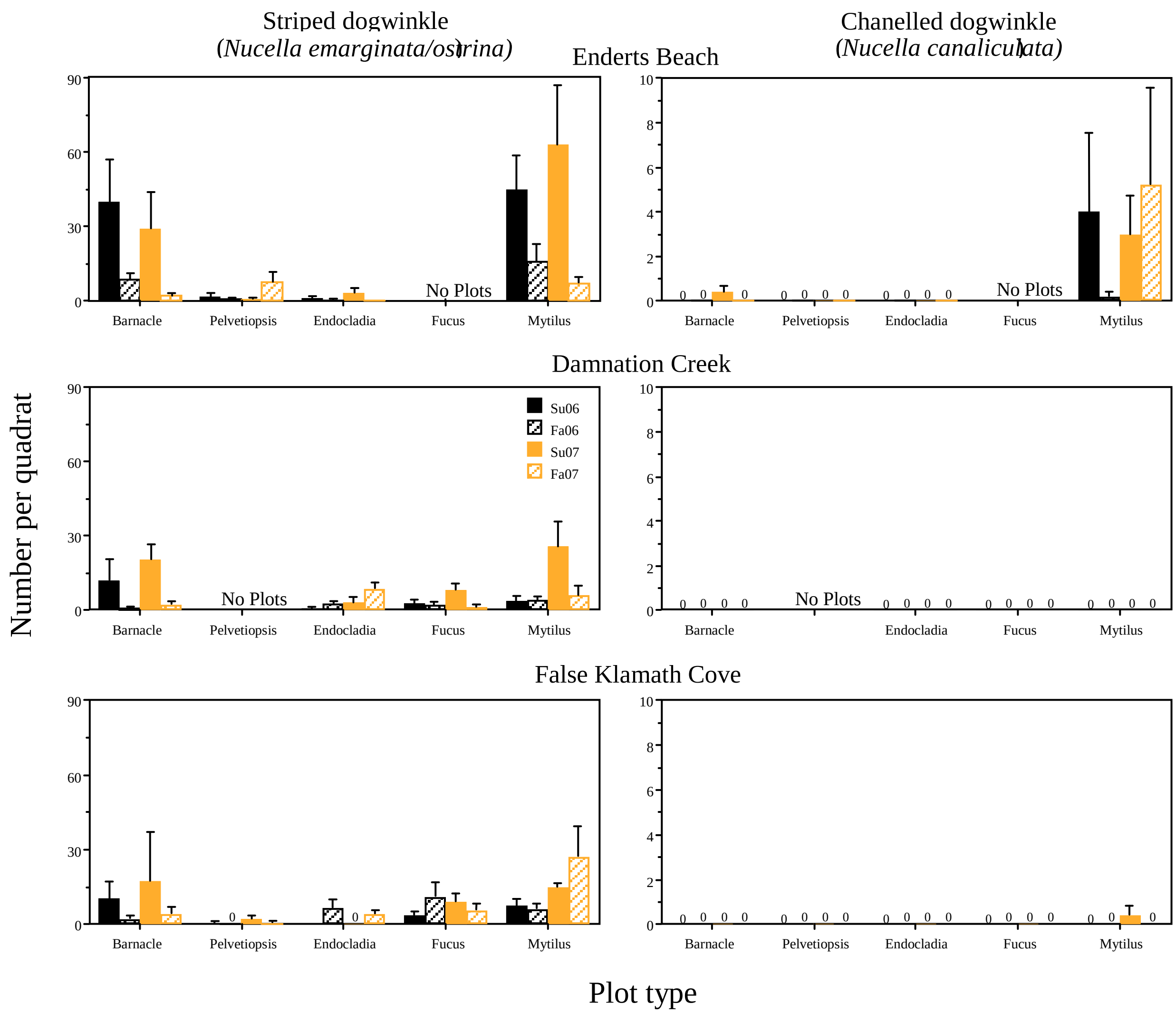

Figure 11. Mean abundances (± 1SE) of two species of dogwinkle whelks during 2006-2007 sampling periods. Plot types arranged from high zone (Barnacle on far left) to mid zone (Mytilus on far right). Note different scales on y axes.

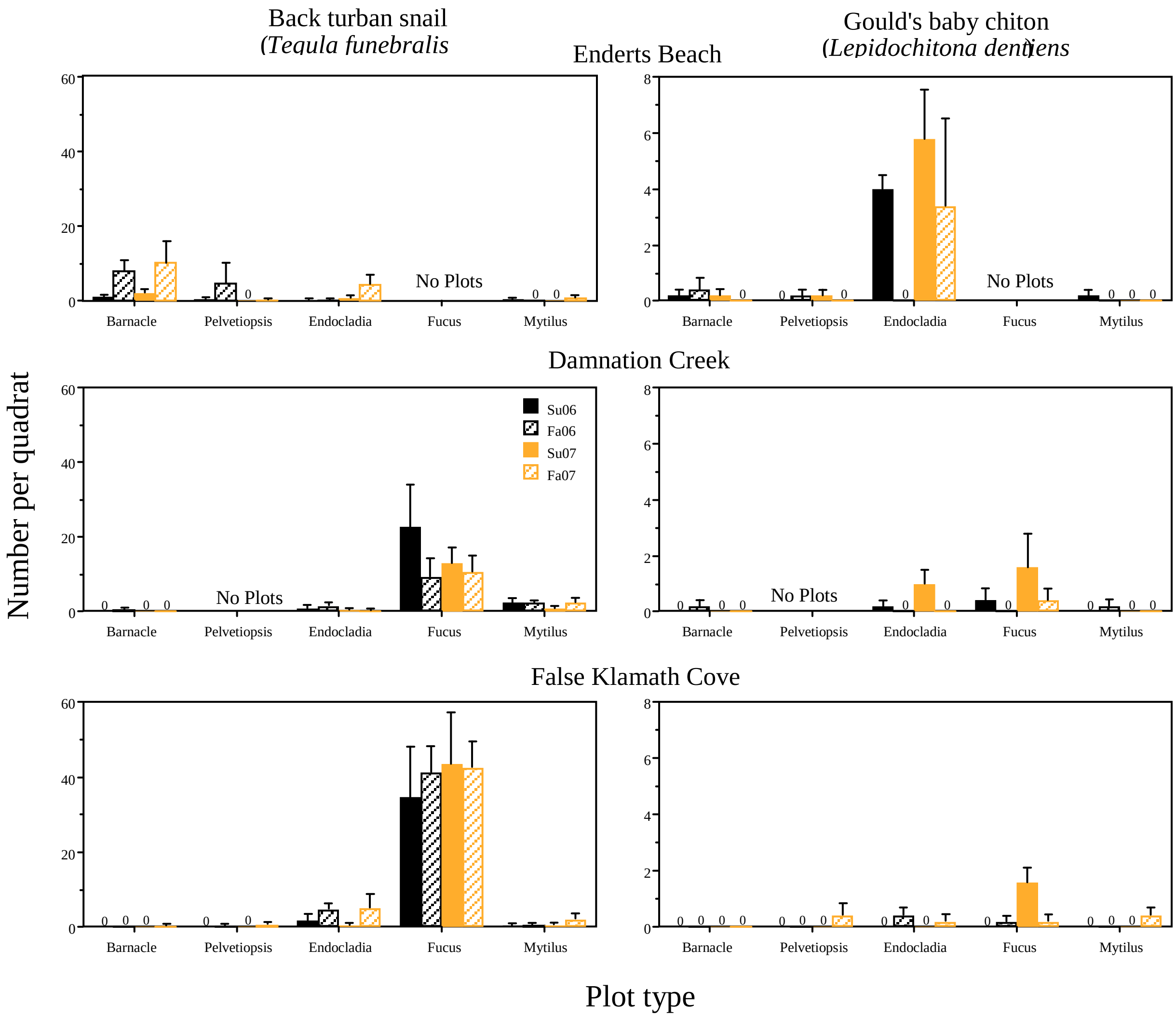

Figure 12. Mean abundances (± 1SE) of Black turban snails and Gould's baby chitons during 2006-2007 sampling periods. Plot types arranged from high zone (Barnacle on far left) to mid zone (Mytilus on far right). Note different scales on y axes.

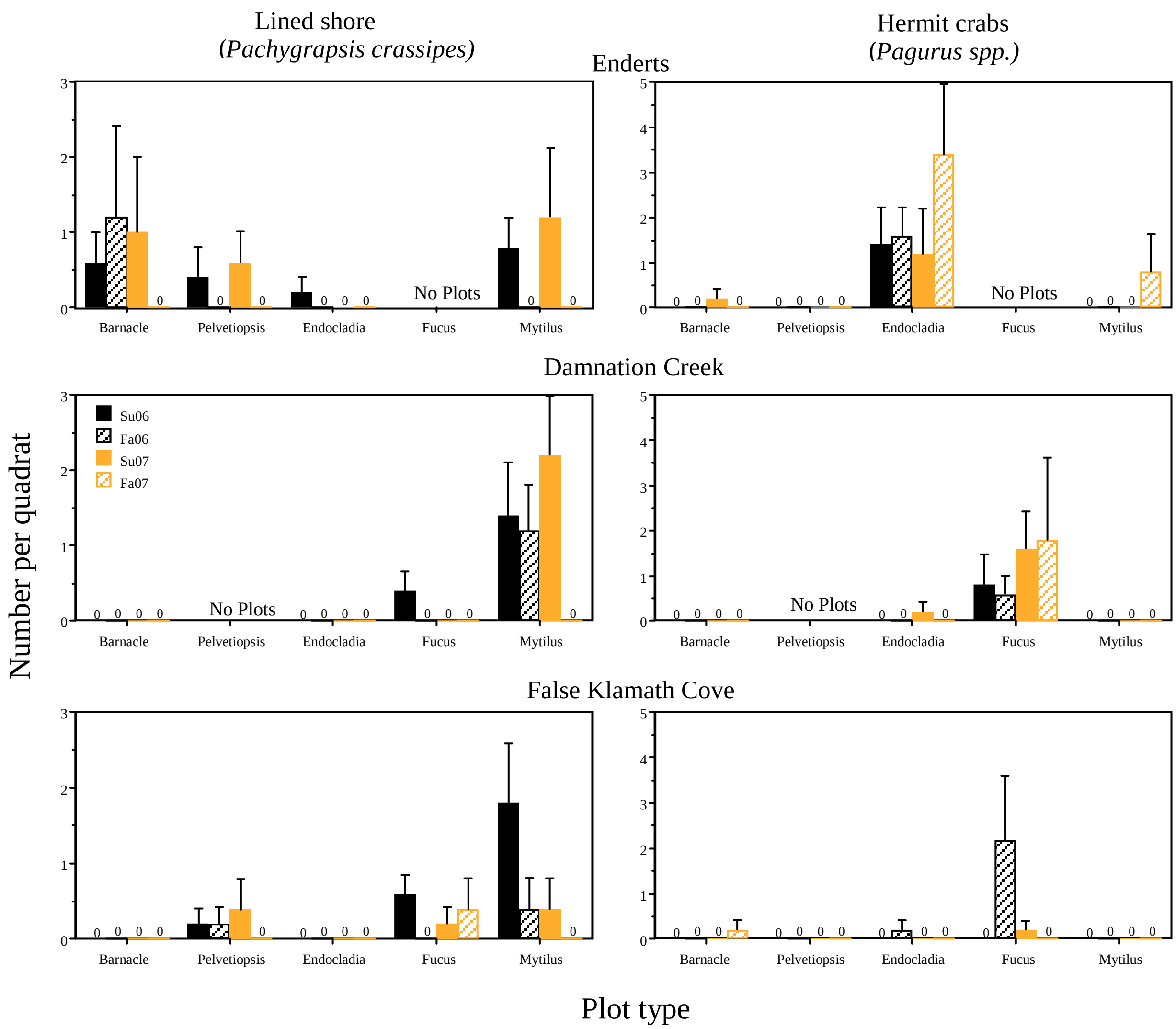

Figure 13. Mean abundance (± 1SE) of lined shore and hermit crabs during 2006-2007 sampling periods. Plot types arranged from high zone (Barnacle on far left) to mid zone (Mytilus on far right). Note different scales on y axes.

Table 9. Presence (X) of less common mobile invertebrate species in plots at RNSP sites during 2006-2007 sampling trips. Sites: Enderts Beach (E), Damnation Creek (D), and False Klamath Cove (F). Note: there are no *Fucus* plots at Enderts and no *Pelvetiopsis* plots at Damnation.

Plot type	**Barnacle**			***Pelvetiopsis***			***Endocladia***			***Fucus***			**Mussel**		
Site	**E**	**D**	**F**	**E**	**D**	**F**	**E**	**D**	**F**	**E**	**D**	**F**	**E**	**D**	**F**
Gastropods															
Acanthinucella spp.					--		X			--					
Alia carinata					--				X	--					
Amphissa spp.					--		X		X	--					
Bittium eschrichtii				X	--					--					
Epitonium tinctum					--			X	X	--					
Fissurella volcano	X				--					--					
Nucella lamellosa					--					--		X			
Ocenebra circumtexta					--					--		X			
Onchidella borealis				X	--	X				--					X
Chitons															
Lepidozona spp.					--			X		--		X			
Mopalia spp.					--				X	--		X			
Nuttallina spp.	X				--					--					
Crabs															
Hemigrapsus nudus					--					--		X			
Pachycheles spp.					--					--				X	X
Petrolisthes spp.					--				X	--				X	
Pugettia spp					--		X			--		X			
Seastars															
Leptasterias spp.					--		X			--			X		
Pisaster ochraceus					--		X			--			X		
Total taxa		2			2			10			6			5	

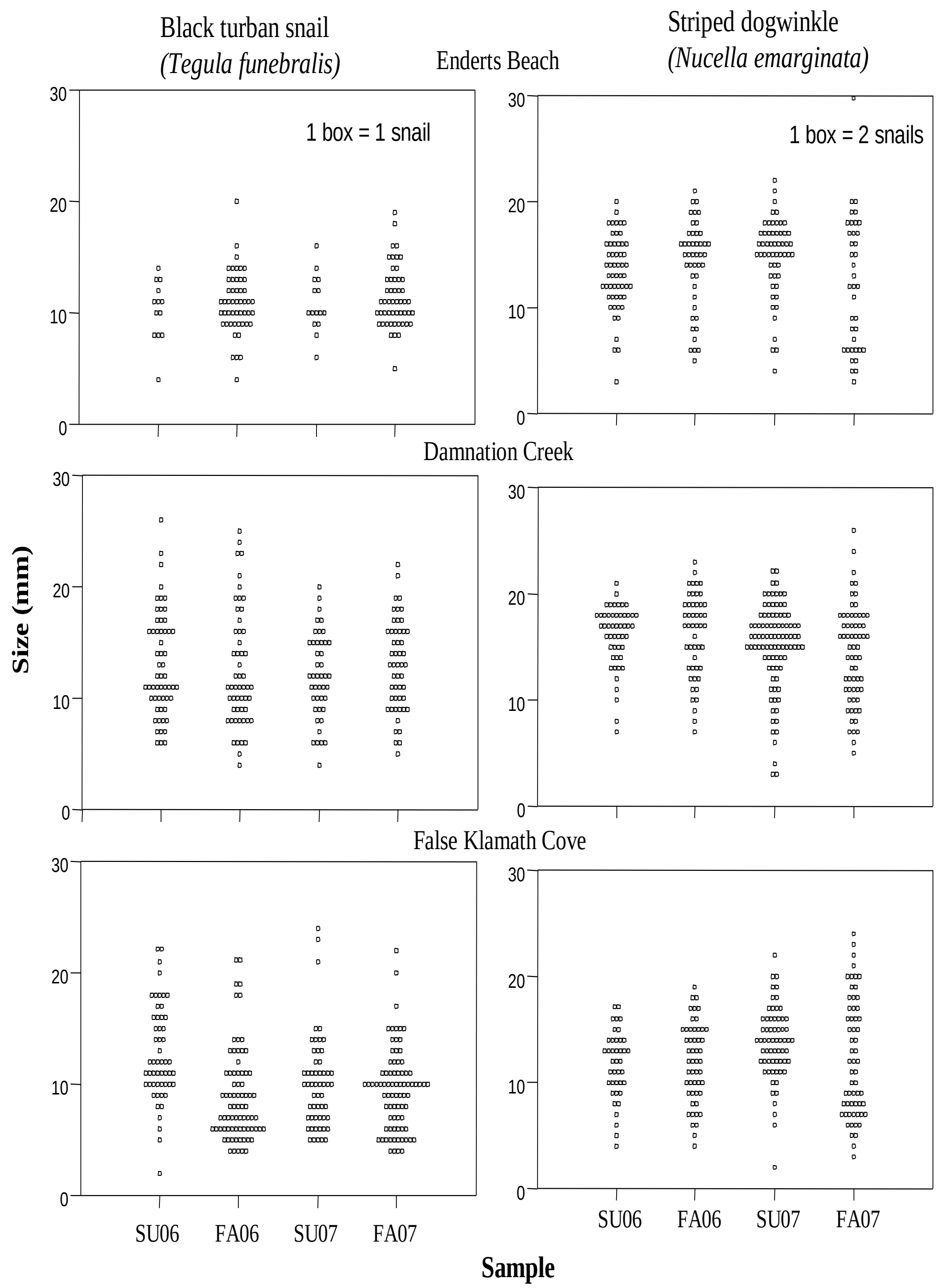

Figure 14. Size frequency distributions of black turban snails and striped dogwinkles at RNSP during 2006 and 2007. The width of each bar represents the abundance of each size class.

Sea Star Plots

Sea star numbers declined over time at both Enderts and Damnation Creek, but not at False Klamath Cove (Figure 15). Abundances of sea stars are not meant to be compared on a per plot basis since plots were established in areas of high sea star densities in order to “target” the species. The observed ratio of the two color morphs is consistent with the average ratio reported from sites throughout the California coast (Raimondi et al. 2007).

The size structure of the Ochre sea star populations differed among the three sites (Figure 16). The population at False Klamath Cove comprised mostly small individuals, the population at Damnation Creek mid-sized individuals, and the population at Enderts Beach was equally distributed among size classes.

Surfgrass Transects

In both fall 2006 and fall 2007, large waves did not allow surfgrass surveys at Damnation Creek. However, visual observations during these surveys suggested that the plants looked healthy. During the summer surveys, surfgrass abundance was high (90 and 92%) in both 2006 and 2007 and showed little variation.

Sea Surface Temperature

Sea surface temperature varied both within and among years (Figure 17). There was little temperature variation between RNSP sites, so the graph shown is the average sea-surface temperature recorded from the three sites. Seasonal and annual variations will be further utilized to explore ecological patterns in future trend reports.

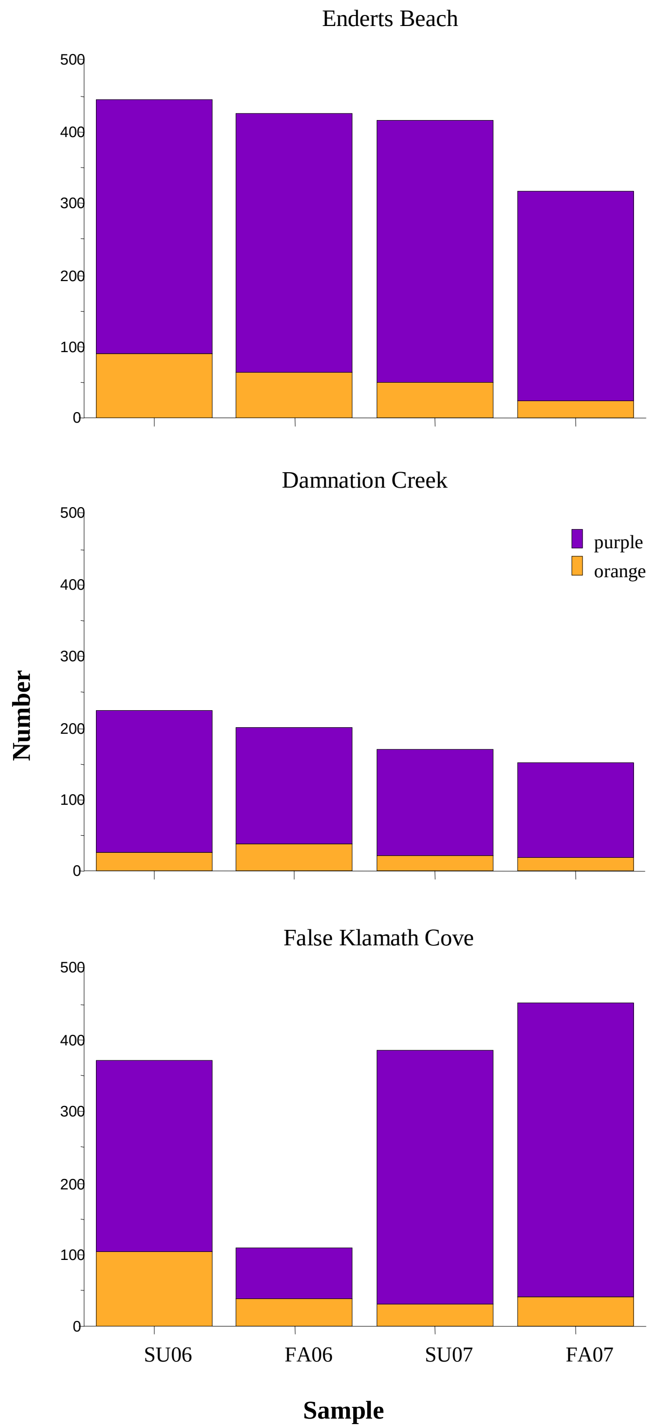

Figure 15. Number of Ochre sea stars (*Pisaster ochraceous*) at three sites within the RNSP during sampling periods in 2006 and 2007. Numbers are divided into the two color morphologies: purple/“other” and orange.

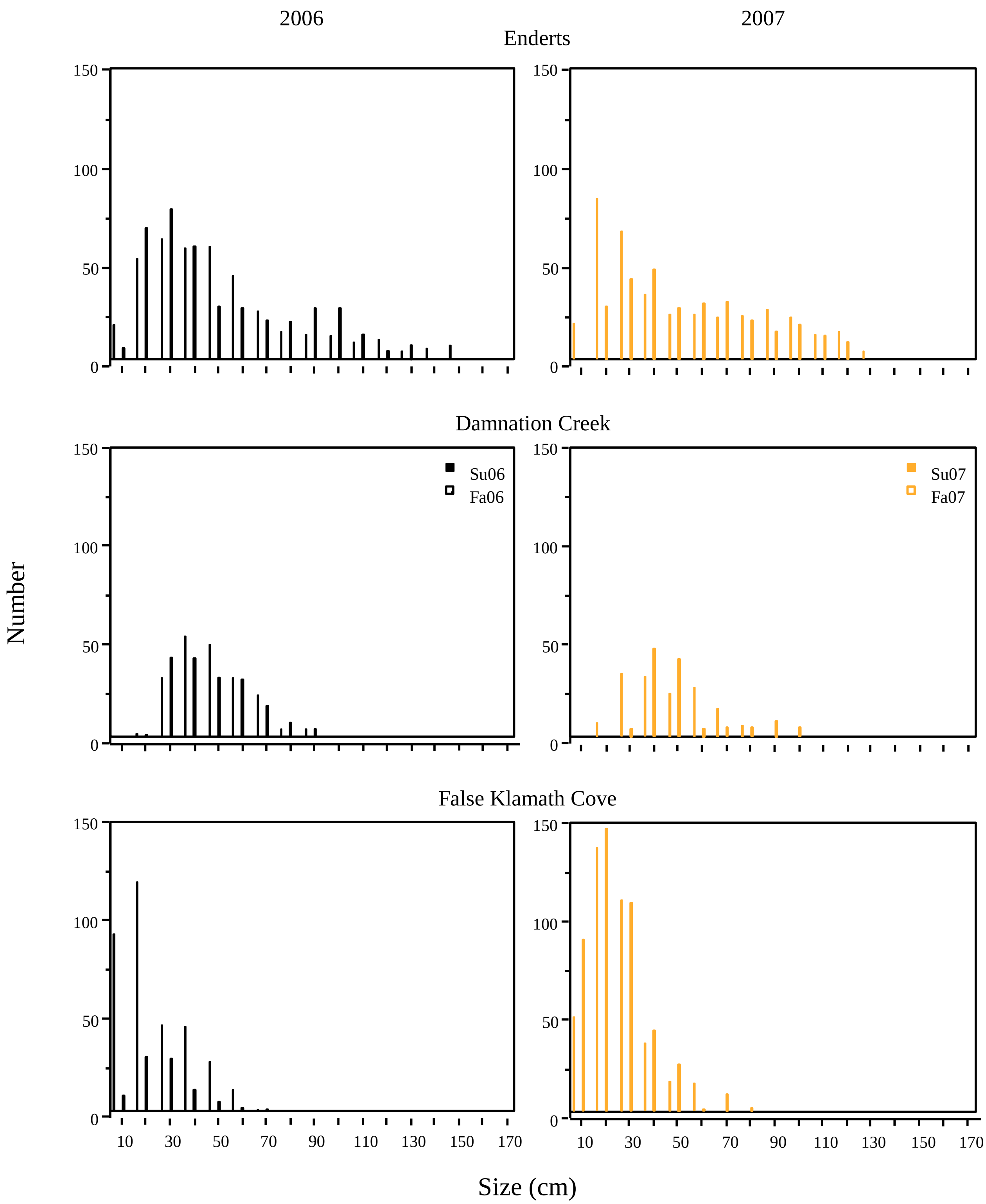

Figure 16. Size distributions of Ochre sea stars (*Pisaster ochraceous*) at three sites within the RNSP during sampling periods in 2006 and 2007.

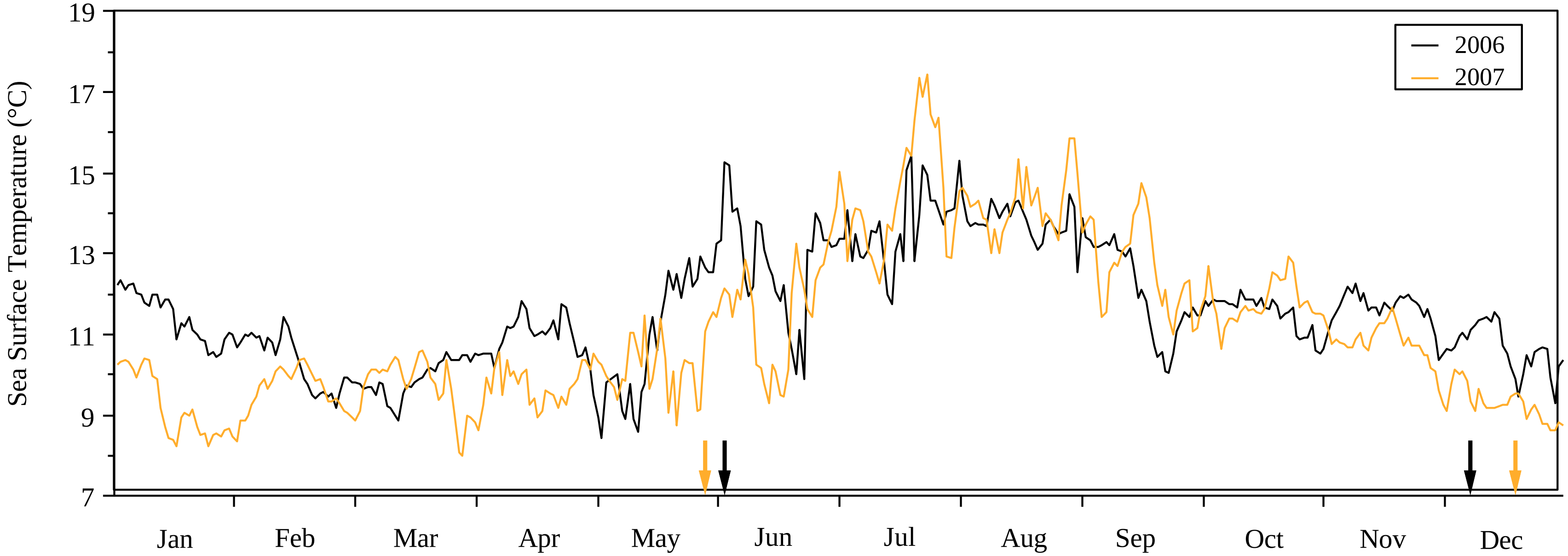

Figure 17. Average sea-surface temperatures from three RNSP sites from 2006 to 2007. Arrows denote sampling period for each year. Data collected with Onset brand temperature loggers.

Discussion

A primary objective of the RNSP monitoring program is to track changes in the structure of the intertidal community over time. To accomplish this, data on the distribution, abundance, and sizes of species found at several sites within RNSP are collected. Such data, when collected over long periods of time, not only increase our understanding of the processes that affect intertidal communities but can also alert researchers/managers about unusual conditions occurring in monitored areas, including shifts in species ranges due to global climate change (Barry et al. 1995, Sagarin et al. 1999) and the introduction of non-native species (Carlton and Geller 1993).

As the RNSP intertidal monitoring dataset grows, patterns will emerge and the usefulness of these data will increase. We will start to gain understanding in seasonal and annual variation, so that disturbance or long-term trends will become detectable. An increase in the temporal breadth of the dataset is necessary to draw conclusions about trends and to realize deviations from baseline conditions. From the photoplots, we get information about the cover of algae and sessile invertebrates but it is difficult to see smaller snails, crabs, and chitons from the photos. These species are generally small, cryptic, and often hidden beneath other organisms. Mobile invertebrate counts are employed to gain a better understanding of the whole intertidal community. We expect to see further patterns related to zonation, for example littorines being most abundant in the barnacle zone. The sea star plots and surfgrass transects allow us to track changes of target populations.

Initial results from the RNSP monitoring program indicate there have been no large changes to the structure of the intertidal community over the study period. However, comparisons between current assessment and those made by Boyd and DeMartini (1977) indicate a strong successional shift from a highly disturbed community to a more stable, late successional community. Percent cover variation resulting from small scale spatial clearance has also decreased since the earlier study periods. Historically, community differences may be attributed to increased sediment loads and higher quantities of driftwood at rocky intertidal sites (McGary 2005). Without monitoring data before and after the years of intense logging, it is not possible to directly assess the impacts of increased sediment loads and driftwood scouring intertidal communities. This highlights the need for continued monitoring. In the event that degradation was to occur from natural or anthropogenic drivers, monitoring data would enable managers to assess the impacts and determine biological responses (Raimondi et al. 1999).

Such monitoring programs are particularly needed in California, which is moving rapidly toward a new era of marine resource management that includes greater emphasis on dealing with the impacts of humans on marine ecosystems. Calls for this “ecosystem-based management” approach to manage marine resources and ecosystems are reflected in the recommendations of the US Commission on Ocean Policy, the Pew Commission Report, and the California Ocean Protection Act. Long-term monitoring studies provide important information not only about the current state of populations and communities but also about whether and how much they change over time.

The rocky intertidal monitoring program in RNSP is off to a successful start, with a comprehensive, field-tested protocol that involves data collection at three sites on a biannual sampling regimen. These findings will inform managers and policymakers and facilitate marine conservation through public outreach. This monitoring program will inform the Marine Life Protection Act (MLPA; http://www.dfg.ca.gov/mrd/mlpa/index.html, see also the Marine Life Management Act; http://www.dfg.ca.gov/mrd/mlma/index.html) process by providing essential baseline data for (1) future design of the Marine Protected Area (MPA) network in the northern California region and (2) assessment of the effectiveness of the reserve networks (MPAs) that will be established.

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Appendix A: Species Monitored

Target, Core, and Optional Species Defined

The definitions of monitored species are adapted from the MARINe handbook (Engle 2005).

Target Species: "Target" species (also called key or indicator species) are species or species groups specifically chosen for long-term monitoring. They dominate particular zones or biotic assemblages in rocky intertidal habitats. The criteria for selecting target species include the following:
• Species that are ecologically important in structuring intertidal communities.
• Species that are competitive dominants or major predators.
• Species that are abundant, conspicuous, or large.
• Species whose presence provides numerous microhabitats for other organisms.
• Species that are slow growing and long-lived.
• Species that have interesting distributions along California coasts.
• Species that are found throughout California shores.
• Species that are characteristic of discrete intertidal heights.
• Species that are rare, unique, or found only in a particular intertidal habitat.
• Species that are approaching their biogeographic limits in California.
• Species that have been well studied, with extensive literature available.
• Species that are of special human interest.
• Species that are vulnerable and/or sensitive to human impacts, especially from oil spills.
• Species that have special legal status.
• Species that are introduced or invasive.
• Species that are harvested by sport or commercial activities.
• Species that are practical for long-term monitoring.
• Species that are readily identifiable and non-cryptic.
• Sessile or sedentary species that are of reasonable size.
• Species that are located high enough in the intertidal to permit sufficient time to sample.

Currently, there are **18 designated target species monitored by MARINe***: *Egregia mensiezii*, *Fucus gardneri*, *Hedophyllum sessile*, *Hesperophycus californicus*, *Pelvetiopsis limitata*, *Silvetia compressa*, *Endocladia muricata*, *Neorhodomela larix*, *Phyllospadix scouleri/torreyi*, *Anthopleura elegantissima/sola*, *Mytilus californianus*, *Lottia gigantea*, *Haliotis cracherodii*, *Chthamalus dalli/fissus/Balanus glandula*, *Semibalanus cariosus*, *Tetraclita rubescens*, *Pollicipes polymerus*, and *Pisaster ochraceus* .
*underlined species are currently monitored at RNSP sites.

Designated target species have the highest priority for monitoring. They are monitored at as many sites as possible. If the species is present in sufficient numbers and it is logistically possible, plots or transects are established to monitor it. More information on target species (e.g., photos and how to identify) can be found on the MARINe public web site.

Core Species: "Core" species are those **species, species groups, or substrates that are scored using one or more survey methods by everyone in MARINe**. Core species must be reasonably and consistently identifiable using the designated scoring protocol (e.g., from labscored photos of fixed plots possibly supplemented by plot sketches/notes). They also must be important enough to warrant scoring for abundance trends. Some of these species only occur at northern sites, or conversely, southern sites, yet to ensure that we notice if they expand their range, we must score everywhere. All target species are core species. It is important that **scorers in all monitoring groups be able to identify and record all core species. Datasheets must include all core species**, though core species that are absent or rarely occur at a site can be deemphasized. Entries for all core species will be required for data submission to the MARINe database.

Optional Species: “Optional” species are **non-core species or species groups that one or more monitoring groups choose to score at their sites; however, for various reasons, are not appropriate or feasible for all groups to score**. Since optional species will not be scored by everyone, coast-wide comparisons of trends for these species will be limited or not possible. However, all groups sampling MARINe north sites (NorCal, RNSP and Oregon) use the same list of optional species.

Appendix B: Natural History of Target Species

These brief descriptions provide context for the selection of these target species by including information on life history, ecological importance, and sensitivity to anthropogenic activities. Descriptions of the natural history of the target species monitored in this study have been adapted with permission from the MMS report (Miner et. al. 2005).

Endocladia muricata

Distinctive dark bands of the low-growing red turfweed, *Endocladia muricata*, are characteristic of nearly all high rocky intertidal shores of the northern Pacific Coast. *Endocladia* forms dense 4-8 cm tall, perennial tufts made up of tiny spine-covered branchlets (Abbott and Hollenberg 1976). Together with spiny-bladed *Mastocarpus papillatus*, the *Endocladia*/*Mastocarpus* carpet traps sediment and seawater, thus providing a sheltered microhabitat for a host of small organisms, including other algae, worms, crustaceans, and mollusks. Glynn (1965) found over 90 species associated with *Endocladia* clumps in Monterey. Turfweed can also provide habitat for attachment of young mussels. Expanding mussel patches may displace *Endocladia*, but it can then grow on the mussel shells, creating a layered assemblage. Some *Endocladia* clumps appear donut or crescent-shaped; this condition may be caused by storms tearing out center areas possibly weakened by accumulated anoxic sediment. *Endocladia* is hardy and quite resistant to desiccation, yet vulnerable to oiling from spills. Recovery from natural or human disturbances may vary from 1 to more than 6 years (Kinnetics 1992).

Phyllospadix spp.

Surfgrass (*Phyllospadix* spp.) is one of only two types of marine flowering plants on the west coast. Surfgrass attaches by short roots to rock on surf-swept shores from the low intertidal down to 10-15 m depths. The 0.5-2 m tall bright green grass commonly occurs in dense perennial beds formed primarily by vegetative growth from spreading rhizomes. Two species (*P. torreyi* and *P. scouleri*) overlap in geographical distribution and morphological characteristics (see Dawson and Foster 1982). *P. torreyi* generally has longer (1-2 m), narrower (1-2 mm) leaves, longer flower stems with several spadices, and occurs more in semi-protected habitats as well as at deeper depths. *P. scouleri* tends to have shorter (<50 cm), broader (2-4 mm) leaves, shorter flower stems with 1-2 spadices, and is found more often in wave-swept intertidal areas. Surfgrass meadows are highly productive ecosystems, providing structurally complex microhabitats for a rich variety of epiphytes, epibenthos, and infauna. Some organisms, such as the red algae *Smithora naiadum* and *Melobesia mediocris*, are exclusive epiphytes on surfgrass (or eelgrass) (Abbott and Hollenberg 1976). *Phyllospadix* beds provide nursery habitat for various fishes and invertebrates. Surfgrass cannot tolerate much heat or drying; the leaves will bleach quickly when midday low tides occur during hot, calm-water periods. Surfgrass can be particularly sensitive to sewage discharge (Littler and Murray 1975) and oil pollution (see Foster et al. 1988). Recovery can be relatively rapid if the rhizome systems remain functional, but might take many years if entire beds are lost, because recruitment is irregular and must be facilitated by the presence of perennial turf algae to which surfgrass seeds attach (Turner 1983, 1985).

Chthamalus dalli and *Balanus glandula*

White acorn barnacles, *Chthamalus dalli* and *Balanus glandula*, typically dominate high intertidal zones along the Pacific north coast. Acorn barnacle species can be difficult to distinguish, especially in photographic monitoring. *C. dalli* are smaller (<8 mm) than *Balanus glandula* (<22 mm), which are whiter in color and have differing shell plate arrangements. Acorn barnacles spawn often, at variable times throughout the year (Hines 1978), and settle in extremely high densities (to 70,000 per m^2), forming distinct white bands along the upper intertidal that contains few other invertebrates except littorines and the hardiest limpets. *Balanus* can outcompete *Chthamalus* by crowding or smothering, but *Chthamalus* can occupy higher tide levels than *Balanus*, because it is more resistant to desiccation. Slightly lower down, acorn barnacles mix in with the *Endocladia* assemblage and are common on mussel shells. *Chthamalus* species grow rapidly but only survive a few months to a few years. *Balanus* can live longer (up to 10 years), but its larger size and lower tidal position subject it to higher levels of mortality from predatory gastropods and ochre sea stars.

White acorn barnacles are highly vulnerable to smothering from oil spills because floating oil often sticks along the uppermost tidal levels. Significant, widespread barnacle impacts were reported after the 1969 Santa Barbara oil platform blow-out (Foster et al. 1971) and the 1971 collision of two tankers off San Francisco (Chan 1973). However, high recruitment rates may promote relatively rapid recovery of acorn barnacles; disturbance recovery times ranging from several months to several years have been reported (see Vesco and Gillard 1980).

A condition referred to as “hummocking” was observed in acorn barnacles at several sites. Hummocking occurs in response to high recruitment densities and growth rates, which intensify competition for primary substrate space (Bertness et al. 1998). This condition causes crowded barnacles to grow up instead of out until they eventually grow so high that they are susceptible to removal by wave action. Evidence of hummocking was observed at all three monitored sites within RNSP. Frequently, large patches of barnacles would be entirely removed from one sampling period to the next.

Mytilus californianus

The California mussel, *Mytilus californianus*, is abundant at middle to low levels of exposed rocky shores along the entire Pacific Coast. These 10-20 cm black/blue/gray mussels firmly attach to rocks or other mussels by tough byssal threads, forming dense patches or beds. The literature on *Mytilus californianus* is extensive, including key ecological studies on the effects of predation, grazing, and disturbance on succession and community structure (Morris et al. 1980, Ricketts et al. 1985, Kinnetics 1992). Thick (>20 cm) beds of California mussels trap water, sediment, and detritus that provide food and shelter for an incredible diversity of plants and animals, including cryptic forms inhabiting spaces between mussels as well as biota attached to mussel shells (Paine 1966, MacGinitie and MacGinitie 1968, Kanter 1980, Lohse 1993). For example, MacGinitie and MacGinitie (1968) counted 625 mussels and 4,096 other invertebrates in a single 25 cm^2 clump and Kanter (1980) identified 610 species of animals and 141 species of algae from mussel beds at the Channel Islands. Mussels feed on suspended detritus and plankton. Young mussels settle preferentially into existing beds at irregular intervals, grow at variable rates depending on environmental conditions, and eventually reach ages of 8 years or more (see Morris et al. 1980, Ricketts et al. 1985). Mussels can tolerate typical rigors of intertidal life quite successfully. However, desiccation likely limits the upper extent of mussel beds, storms tear out various-sized mussel patches, and sea stars prey especially on lower zone mussels. *Mytilus* are adversely affected by oil spills (Chan 1973, Foster et al. 1971). Recovery from disturbance varies from fairly rapid (if clearings are small and surrounded by mussels that can move in) to periods greater than 10 years (if clearings are large and recruitment is necessary for recolonization (Vesco and Gillard 1980, Kinnetics 1992).

Pisaster ochraceus

The ochre sea star, *Pisaster ochraceus*, is found on middle and low tide levels of waveswept, rocky coasts from Alaska to Baja California. Its relatively large size (up to 45 cm diameter), variety of colors (yellow, orange, purple, and brown), and ability to withstand air exposure (at least 8 hours) attract considerable attention from visitors exploring the shore at low tide. The ochre sea star typically is associated with mussels, which constitute its chief food, but barnacles, limpets, snails, and chitons also may be taken (Morris et al. 1980). Predator-prey interactions involving ochre sea stars have been intensely studied, especially the role of *P.ochraceus* in determining the lower limit of northern mussel beds (Paine 1966, 1974; Dayton 1971). Ochre sea stars are relatively slow-growing, long-lived, and apparently variable in recruitment success. They are tolerant of high surf, using their numerous tube feet to remain firmly in place, often in cracks and crevices. They have few predators, except for curious tidepool visitors. Sensitivity to oil spills is not well known; Chan (1973) saw no obvious effects from a San Francisco oil spill. Recovery time from any major population loss likely would be very long.

Pelvetiopsis limitata

The rockweed, *Pelvetiopsis limitata*, is described as light tan to olive; densely branched, cylindrical at the base becoming flattened to cylindrical in the upper fronds; dichotomous; and with thalli 4-8 cm tall (Abott and Hollenberg 1976). This alga is seen commonly in the upper intertidal of more wave-exposed sites in RNSP. *Pelvitiopsis* ranges on the Pacific coast from Vancouver Island, British Columbia, to Cambria (San Luis Obispo County), California. Little scientific attention has been given to *Pelvetiopsis*, so little is known about its reproductive periodicity, longevity, or ecology.

Fucus gardneri

Another common rockweed in RNSP, *Fucus gardneri,* has similar olive brown, branching, dichotomous thalli morphology to *Pelvetiopsis*. It is distinguished by having taller thalli, 10-25 cm, and prominent midribs in older portions (Abott and Hollenberg 1976). This conspicuous brown alga is commonly found in the mid to high intertidal on rocks. Many species of invertebrates find vital shelter from the harsh conditions characteristic of the intertidal, within the fronds of rockweeds such as *Fucus* and *Pelvetiopsis*. Fucus is also a food source for many gastropods (Houghton et al. 1998). Recovery time of *Fucus gardneri* after the Exxon Valdez oil spill of 1989 was studied. Results suggested that the population dynamics and structure did not fully recover 7 years after the spill despite initial biomass recovery (Driskell et al. 2001).

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